



The XXVIII International Conference on
Supersymmetry and Unification of Fundamental
Interactions (SUSY 2021)

Status of DEAP-3600

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On Behalf of the DEAP-3600 Collaboration



Carleton
UNIVERSITY

Canada's Capital University



DEAP Collaboration

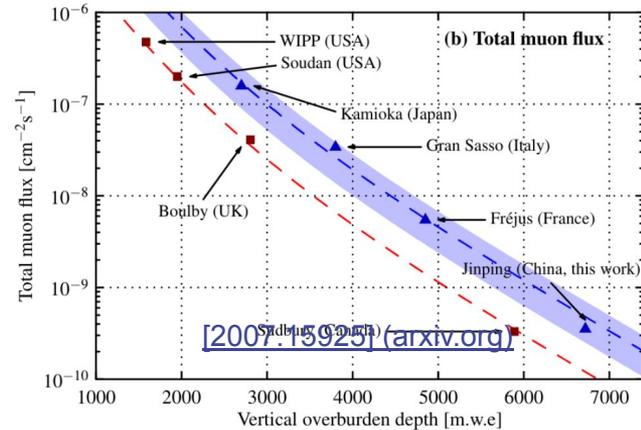
~100 researcher in Canada, Germany, Italy, Mexico, Poland, Russia, Spain, UK, USA



DEAP site

The detector is located at SNOLAB in Sudbury Ontario

A deep underground laboratory which uses the 2 km of rock overburden (provides a ~ 6 k.m.w.e overburden)



DEAP-3600 detector

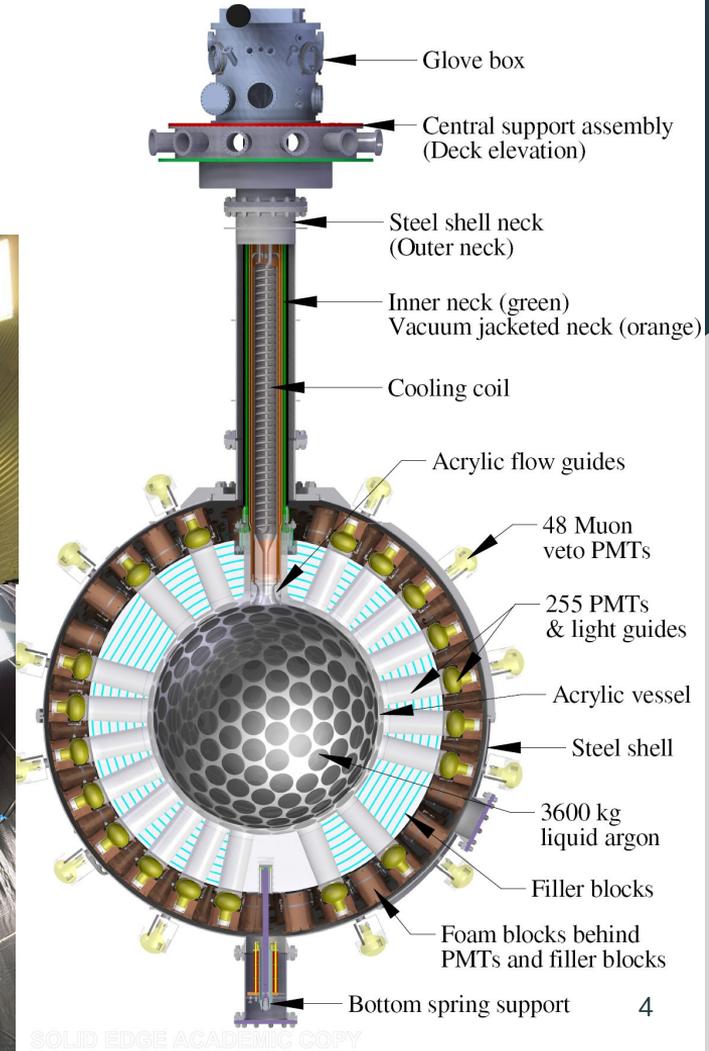
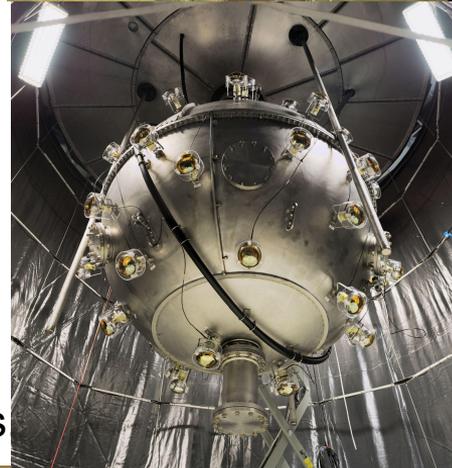
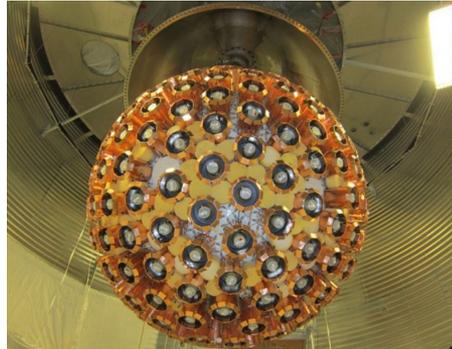
Target : ~3000 kg of LAr in acrylic vessel

Photon detection: 255 HQE PMTs connected via acrylic light guides

Inner surface of vessel coated with TPB wavelength shifter

Shielding: Filler blocks between LGs used for thermal insulation and neutron shielding

Veto: Steel shell is immersed in 300 tons of H₂O, viewed by 48 veto PMTs



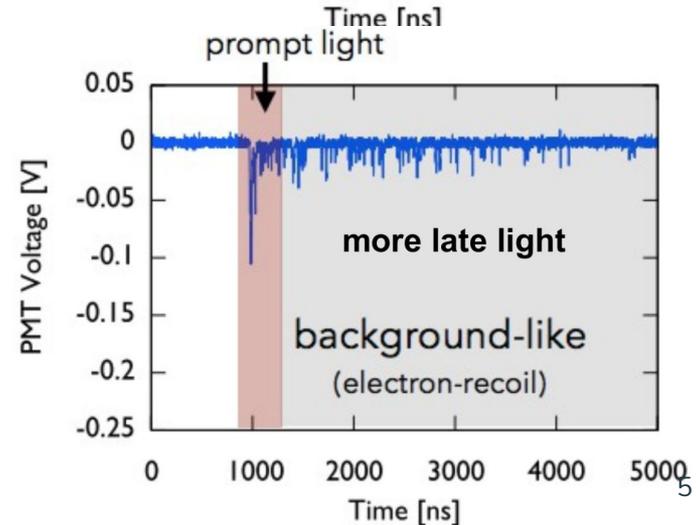
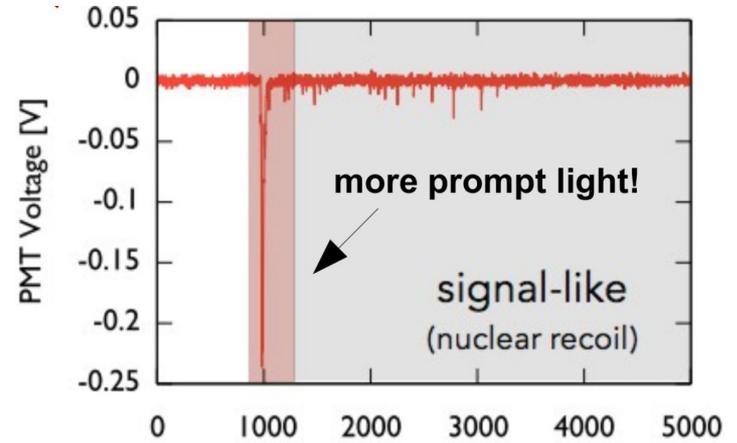
Liquid Argon

It has a good scintillation light yield (40,000 photons/MeV)

Transparent to its scintillation light (128 nm)

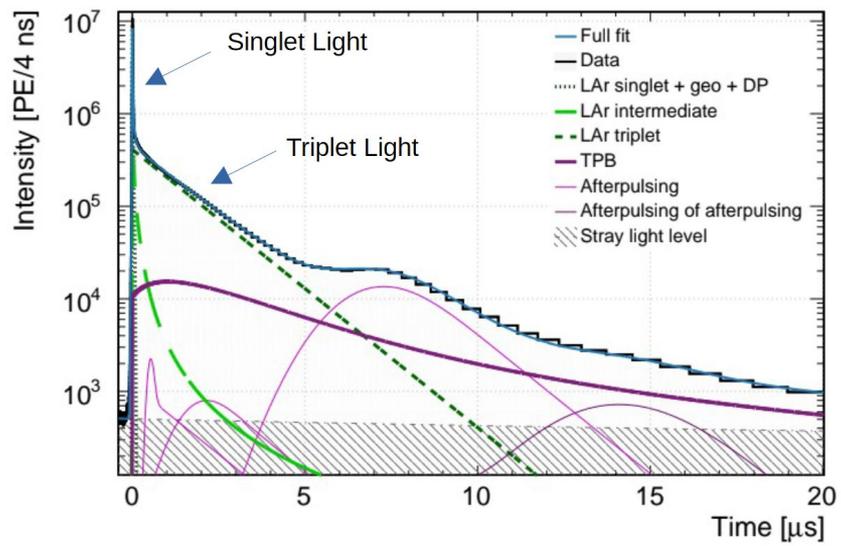
Singlet State (6 ns) \rightarrow Nuclear Recoils (NR)
i.e. (WIMP, α , n)

Triplet State (1.4 μ s) \rightarrow Electron Recoils (ER)
i.e. (β , μ , γ)

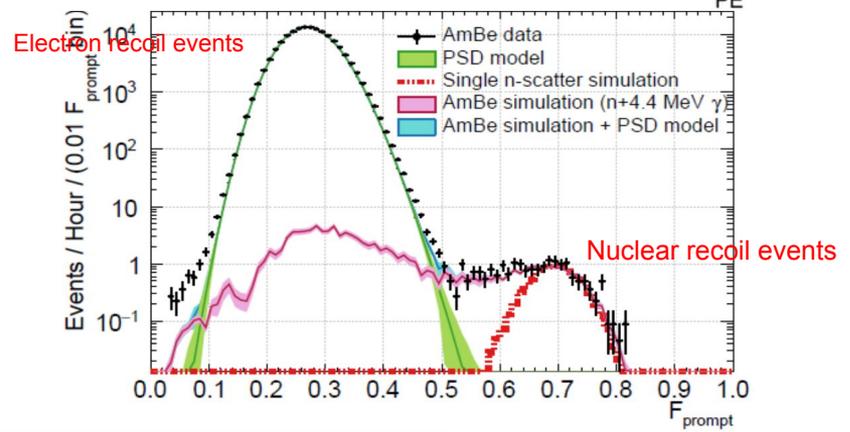
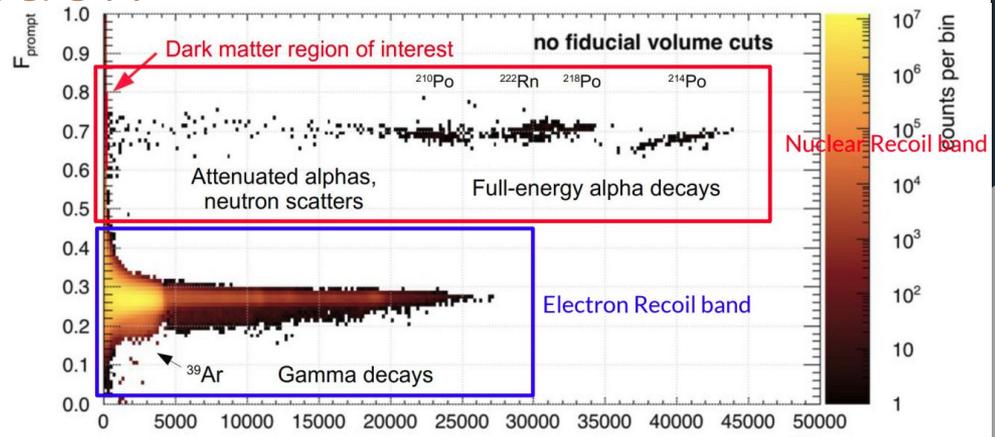


Pulse shape discrimination

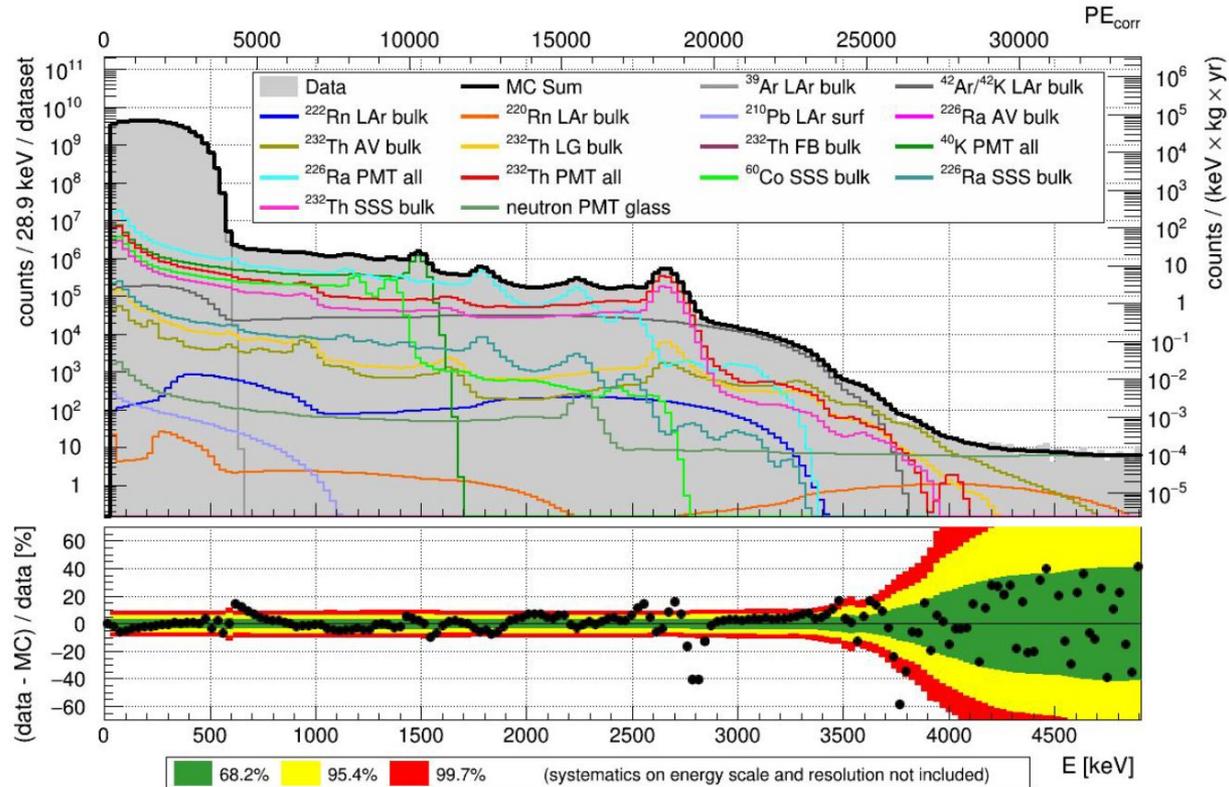
$$F_{prompt} = \frac{\sum_{t=-28\text{ns}}^{60\text{ns}} PE(t)}{\sum_{t=-28\text{ns}}^{10\mu\text{s}} PE(t)}$$



Ar39 pulse shape and model fit including detector effects i.e. TPB response and AP



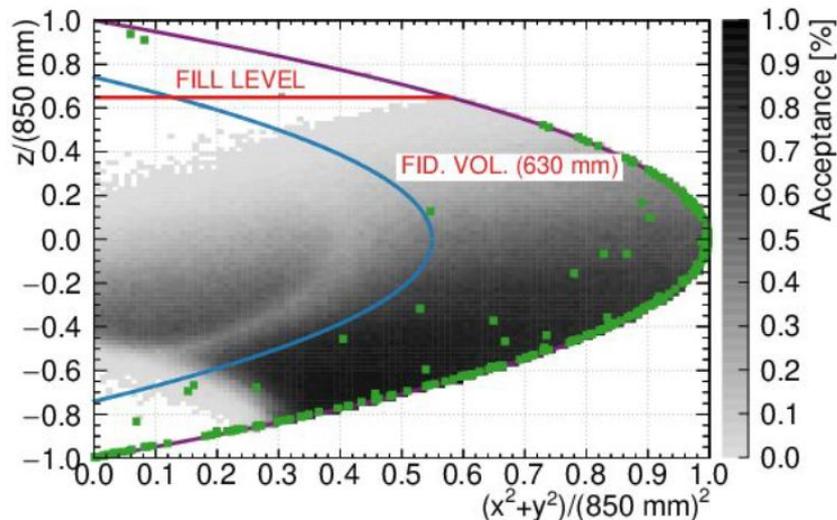
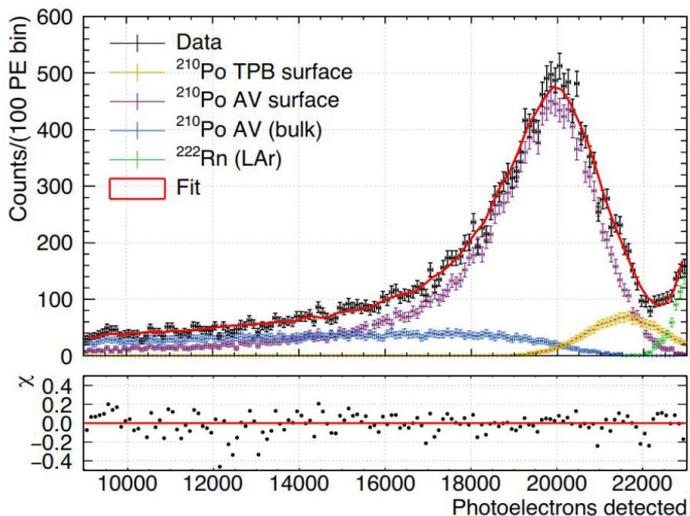
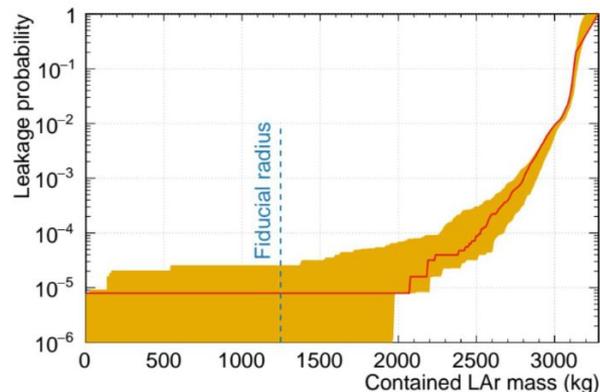
Electromagnetic background



Surface background

Mostly Po-210 decays on the surface of AV

Constrained by the fiducial cut



Neutron background

Cosmogenic Neutrons:

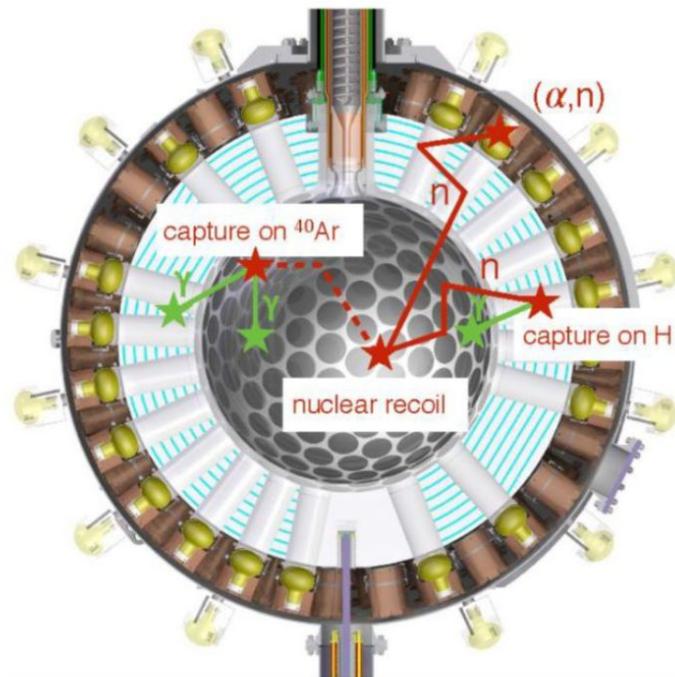
Produced by high energy atmospheric muon: are tagged when passing through muon veto

Radiogenic neutrons:

Produced in the (α, n) reaction triggered by α -decays from Uranium/Thorium chains or by the spontaneous fission of ^{238}U .

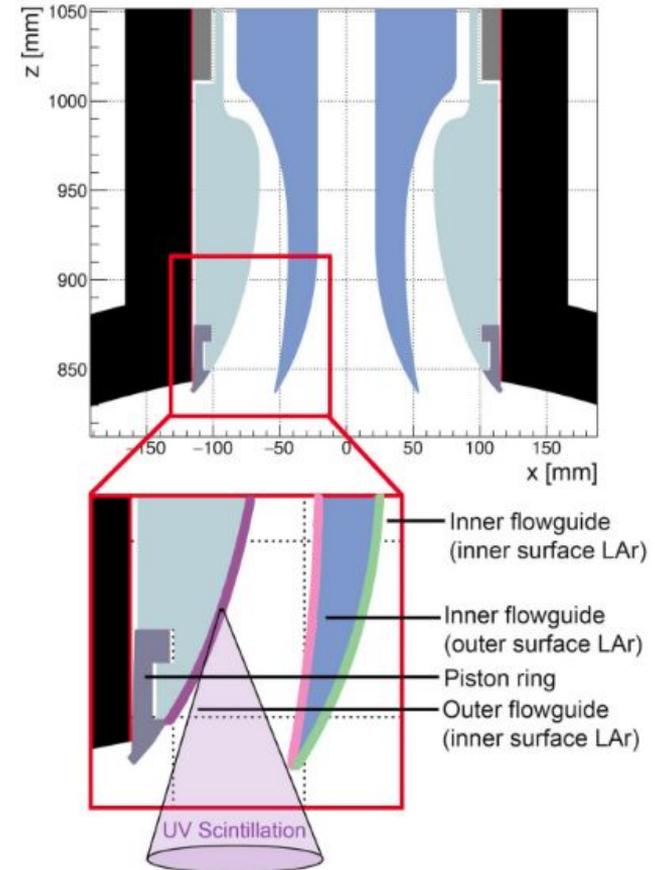
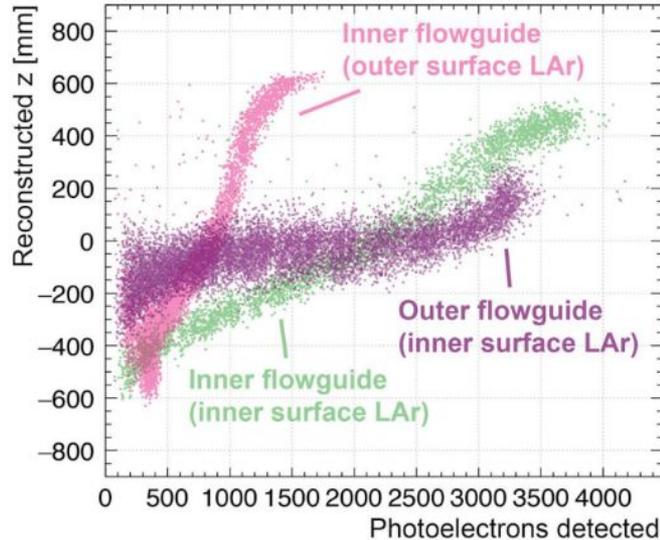
Mitigation process: estimation of flux with material assays

Neutron capture analysis: tagging NR event closely followed (1ms) by high energy ER event



Neck background

Alpha decay by the Po-210 from the surface of the acrylic flow guide located at neck of the detector



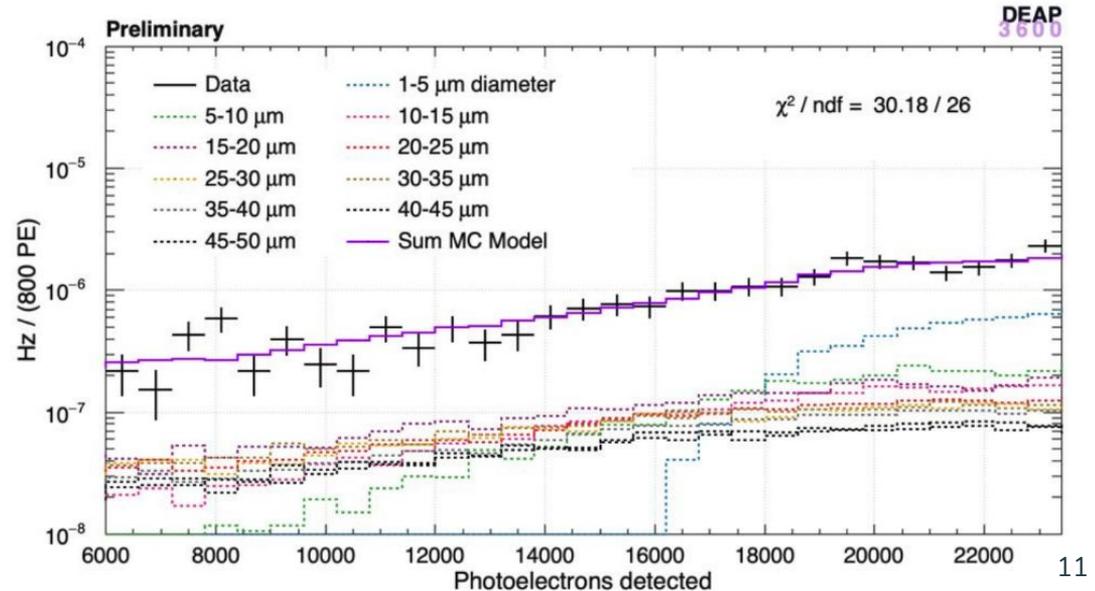
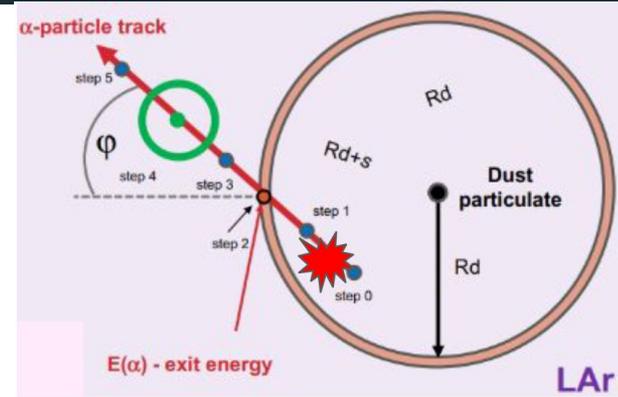
Significant backgrounds on low energy produces due to the shadowed/degraded alpha decays

Dust background

U/Th presents on the dust particulates can be the source of alpha decay

Dust particles shadow the scintillation light and degrade energy of the alpha particle

Different dust sizes are simulated and the particulate size distribution modelled by a power law

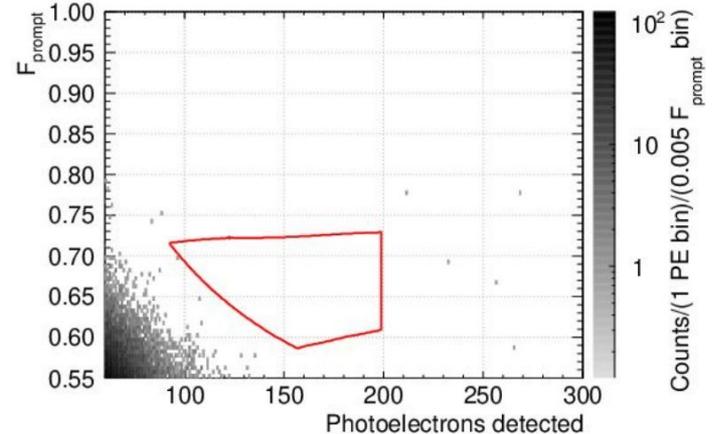
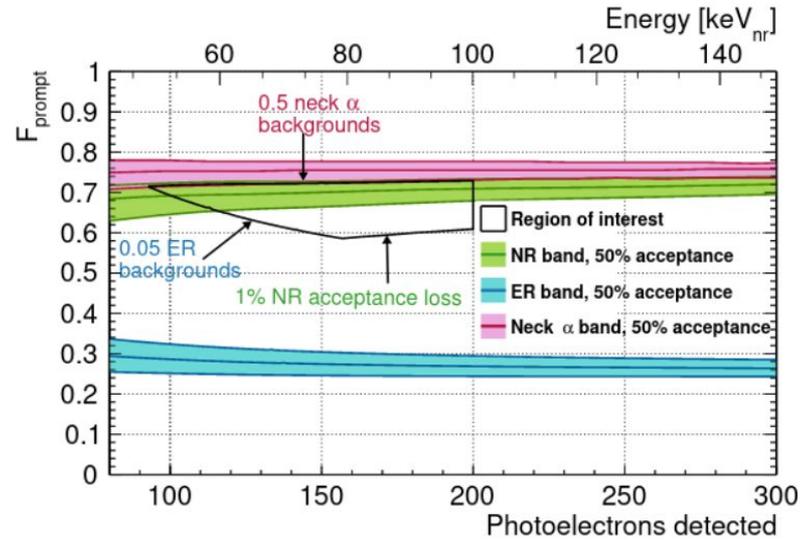


WIMP search

First year dataset (DS) : November 2016 - October 2017 (231 live days)

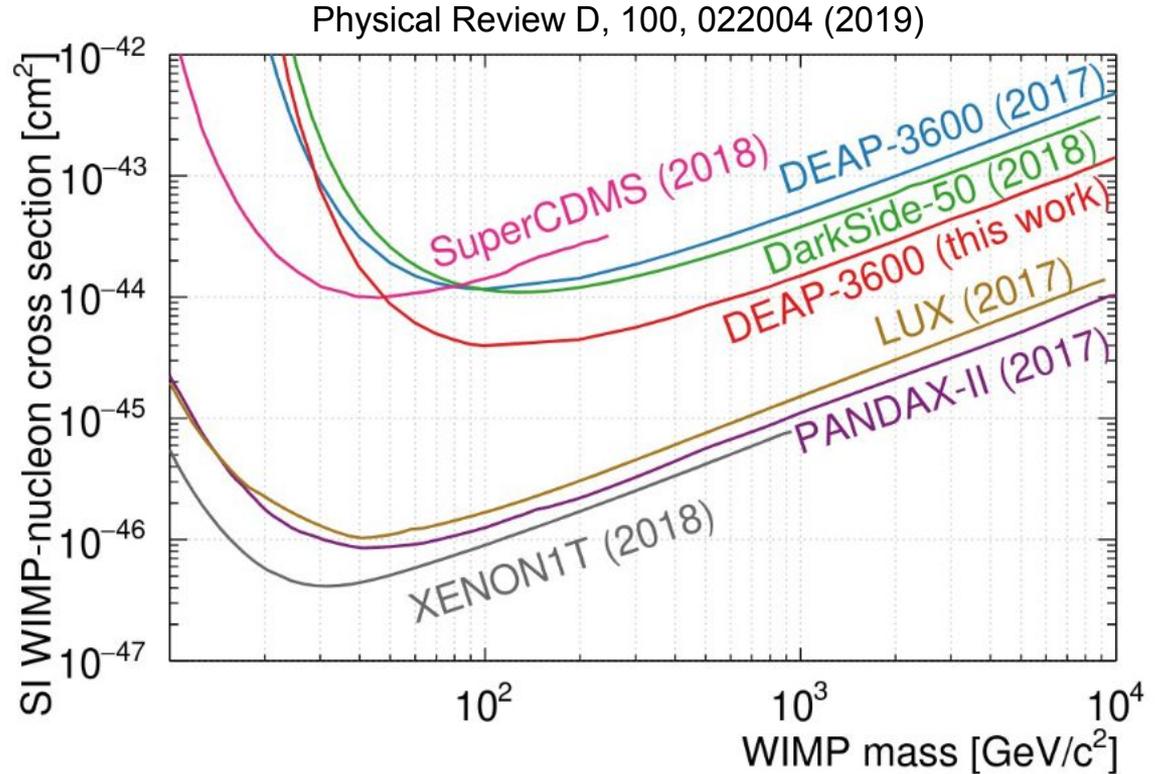
No WIMP-like signals: 0 events in the ROI

	Background rejection cut	WIMP accept. [%]	$N_{\text{bkg}}^{\text{ROI}}$	$N_{\text{obs}}^{\text{ROI}}$
Cherenkov	Neck veto	$92.0^{+1.0}_{-0.1}$	$9.2^{+4.4}_{-3.5}$	29
α -decays in neck	Early pulses in GAr PMTs	$45.4^{+1.5}_{-0.1}$	$2.3^{+1.1}_{-0.9}$	2
	Position fitter consistency	$35.4^{+2.5}_{-0.1}$	$0.62^{+0.31}_{-0.28}$	0
	Total	$35.4^{+2.5}_{-0.1}$	$0.62^{+0.31}_{-0.28}$	0



Sensitivity

Exclude S.I
WIMP-nucleon cross
sections above
 $3.9 \times 10^{-45} \text{ cm}^2$ for 100
 GeV/c^2 WIMP mass
(90% C.L.)



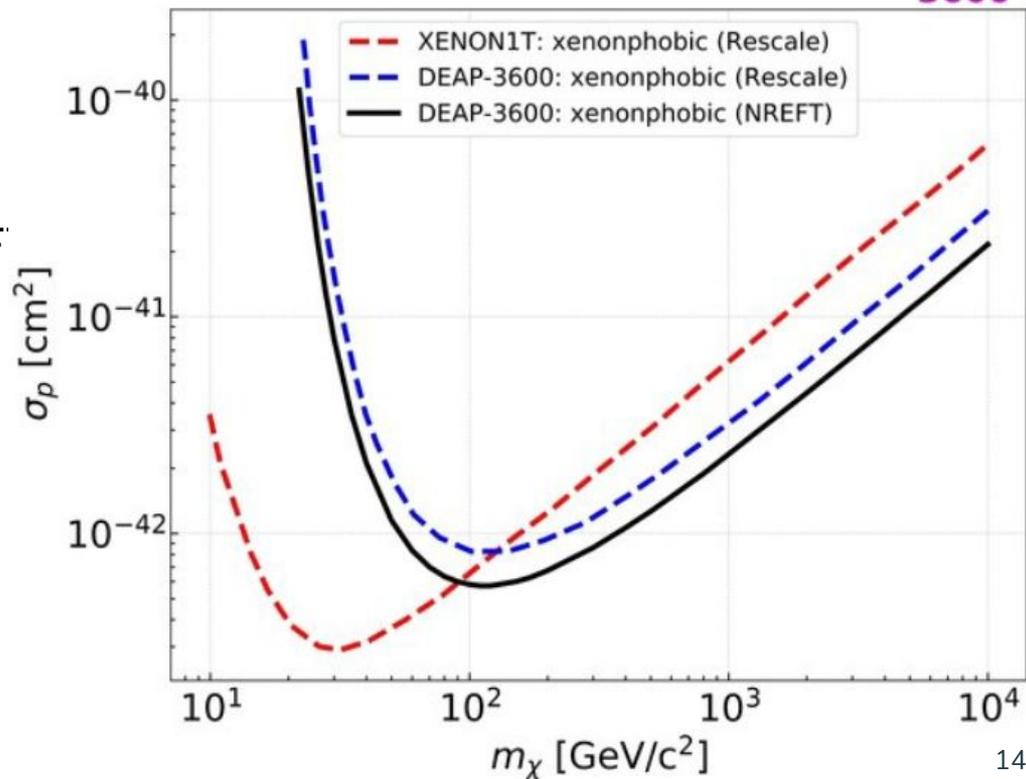
Further Constraints

The results can explore isopin-violating couplings: reinterpreted in a non-relativistic EF framework (NREFT)

Leading sensitivity for isospin-violating xenonphobic DM

<https://arxiv.org/abs/2005.14667>

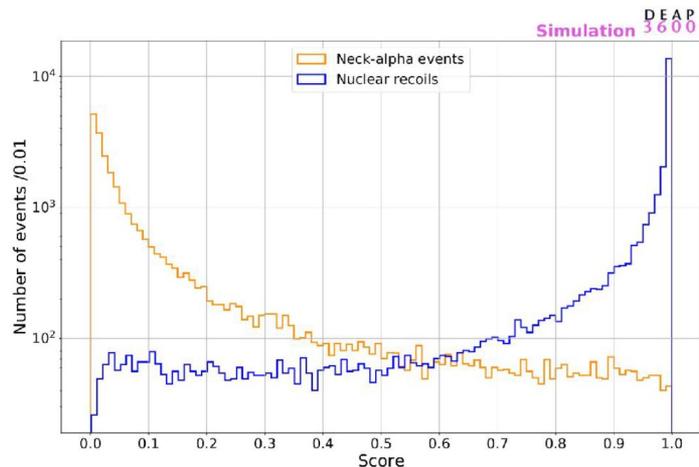
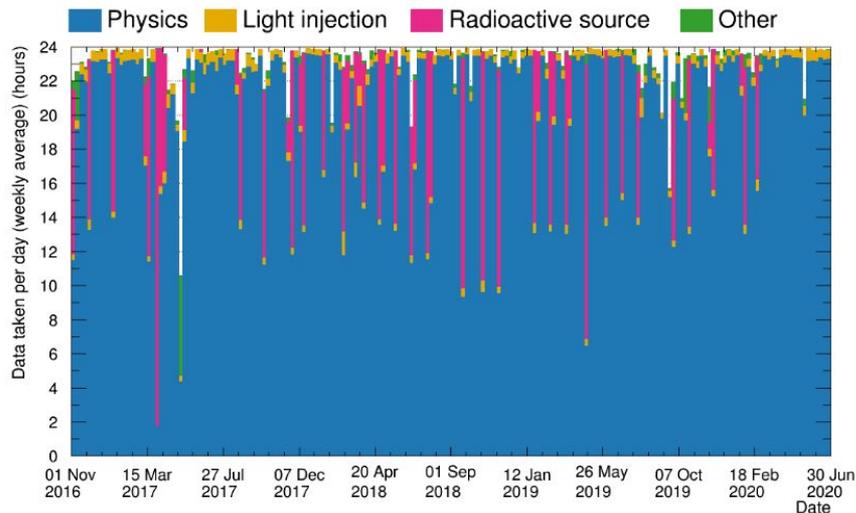
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3600**



Coming up

3 Year Dataset (Nov 2016 to March 2020) expect ~800 days of lifetime instead of 231 days

MVA algorithms (RF, BDT, NN) for background rejection (neck alpha, dust alpha for example)



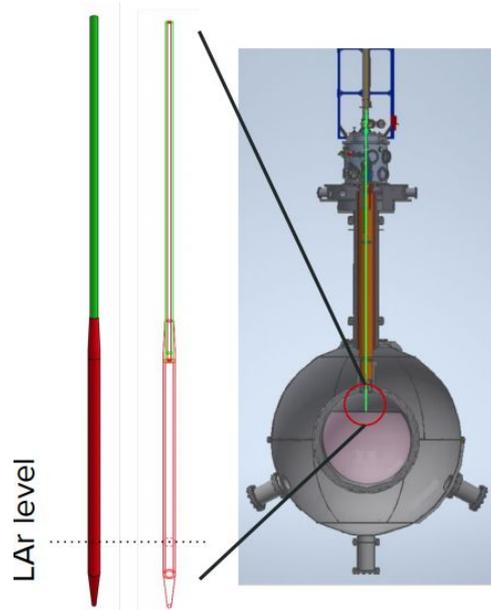
Detector upgrade

Detector upgrades are designed to remove the neck and dust backgrounds.

Warming the neck region to remove possibility of liquid film or droplets forming

Coat the flow guide surfaces with a “slow” WLS - Pyrene is selected

Pyrene has a long decay time : neck events will have lower f_{prompt}



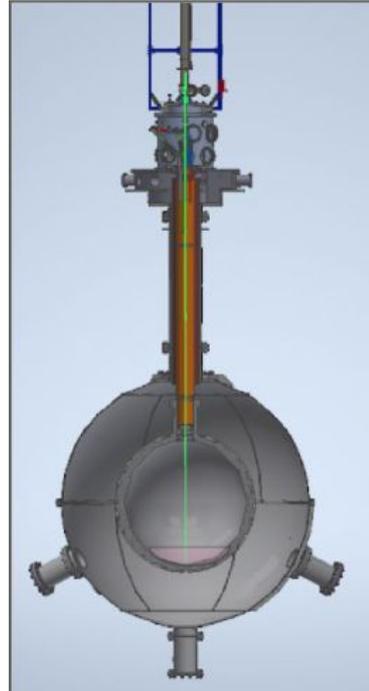
Dust removal

Deployment of stainless steel pipe through the neck of the detector

- syphon liquid argon into external storage dewar

Removal of dust using high purity filter installed in existing gas purification system

Refill AV with clean LAr



Summary

World leading PSD performance in Liquid Argon.

Exclude S.I WIMP-nucleon cross sections above 3.9×10^{-45} cm^2 for 100 GeV/c^2 WIMP mass (90% C.L.).

Reinterpreted results with non-relativistic EFT framework.

Coming up: 3 years Dataset, MVA algorithms, improved background model.

Hardware upgrades work is underway and it should significantly reduce degraded alpha backgrounds.

Thank you for your attention